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BATS FROM NEW CALEDONIA, THE SOLOMON ISLANDS, AND NEW HEBRIDES

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INTRODUCTION

The bats discussed in this paper were collected by Dr. A. J. Nicholson and Mr. Dwain W. Warner during their service with a United States Navy Malaria Control Unit. Most of their time was spent on New Caledonia, where they collected all species known to the island, except *Chalinolobus neocaledonicus* Revilliod. They did not, however, have an opportunity to obtain specimens from the Loyalty Islands. Among the bats from New Hebrides is a new race of *Aselliscus tricuspidatus*. The larger part of this collection was presented to Chicago Natural History Museum, where the identifications have been made by the senior author. The field notes and remarks on habits are the work of the junior author.

A recent report on *The Bacula of Some Fruit Bats (Pteropus)* (Fieldiana, 31, pp. 125–131, figs. 19–20, 1947), by D. Dwight Davis, Curator of Vertebrate Anatomy, Chicago Natural History Museum, was based largely on material from this collection. Mr. Davis has supplied the weights and measurements of embryo *Pteropus ornatus* for this report, and we are indebted to him for these data and for the preparation of the graph (fig. 82).

ACKNOWLEDGMENTS

Plant identifications were made by Dr. E. D. Merrill and Dr. Leon Croizat of the Arnold Arboretum and Dr. Robert T. Clausen of Cornell University. Parasites were identified by Dr. J. Bequeart of the Museum of Comparative Zoology. Acknowledgments also are due Mr. John C. Herron, New Marshfield, Ohio, Mr. Jay B.

Long, Oregon State College, Corvallis, Oregon, and others for assistance in securing and preparing specimens. Unless otherwise stated, photographs were taken by the junior author.

Pteropus ornatus Gray

Pteropus ornatus Gray, Cat. Monk. . . . , p. 105, 1870—New Caledonia.

Specimens examined.—NEW CALEDONIA: Paita and vicinity, 7 males (1 skeleton), 8 females (5 skulls only); Noumea, 3 males,

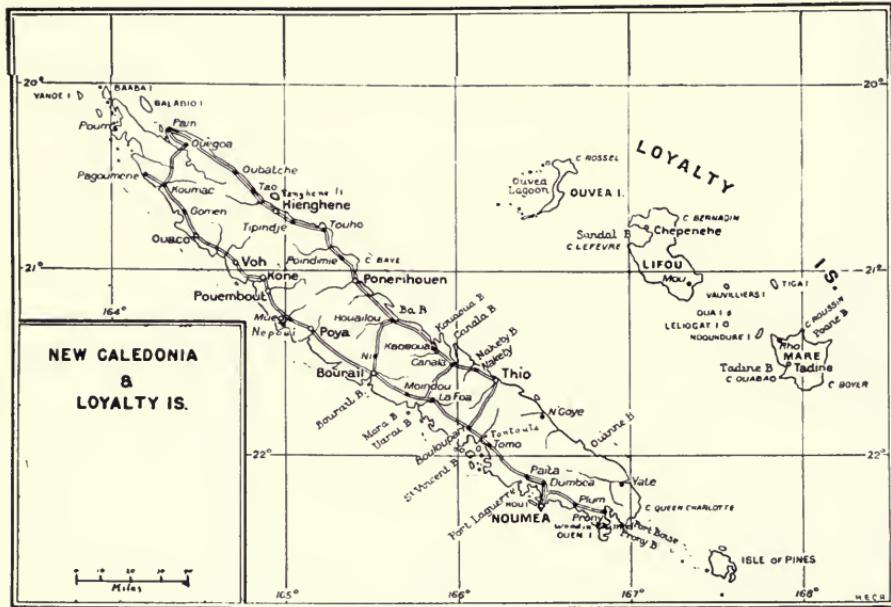


FIG. 78. Map of New Caledonia. See discussion for location of collecting sites.

6 females; Nepoui, 1 female; Houailou, 1 female; Dumbea, 3 males, 1 female; Nakety, 1 female; La Foa, 1 male, 1 female; Tanghene Island, 1 female; twelve miles west of Bouloupari, 8 skulls; near Poya, 11 skulls. Total 59.

There is a great individual variation of color in this series. In nine fully adult specimens the heads vary from Mummy Brown (Ridgway, 1912) in the darkest to Isabella Color in the lightest. The mantle ranges from Warm Buff to Light Buff. In some specimens the back is almost uncolored and in others a broad, light-colored streak extends from the base of the mantle to the rump, so that the back may be entirely dark Mummy Brown or there may

be a streak of Isabella Color. The under parts range from dark Mummy Brown through Auburn to Cinnamon Brown.

Measurements (5 adult males, 3 adult females).—Forearm 153–167.8. Skull: greatest length 70–72.8; condylo-basal length 67–69.5; palatal length 34.9–36.6; interorbital width 8.6–9.6; intertemporal width 6.2–8; zygomatic width 34.4–37.6; mastoid width 20.8–21.9; width of brain case 22.5–23.7; upper toothrow 25.3–27.3; width



FIG. 79. Normal resting position of *Pteropus ornatus*, New Caledonia.

across canines 12.6–14.2; across molars 17.6–19.5; orbit to tip of nasals 23.4–24.7.

Distribution and numbers.—*Pteropus ornatus* (fig. 79) occurs throughout New Caledonia from sea level to at least 3,500 feet. It may be found at higher altitudes (mountains on New Caledonia reach elevations of 5,400 feet); however, on a trip to the top of Mount Mou (4,003 feet), no evidence was found to indicate that this or any other species of flying fox occupies the heavy forest (Foret Noir) commonly found on top of mountains in New Caledonia. En route up the mountain, flying foxes (assumed to be *ornatus*) were observed up to about 3,500 feet. In addition to collected specimens, *ornatus* was positively identified at Woodin Channel, Gomen, Hienghene, and Tontouta.

Although flying foxes are distributed throughout New Caledonia, and may be considered numerous, these animals are not nearly so abundant there as on some of the other Pacific Islands, according to observations made by Dwain W. Warner in the New Hebrides and by the junior author in the Solomon Islands. Populations on all these islands apparently are extremely limited in comparison to those of Australia, when one contemplates the numbers reported for that country by Ratcliffe (1931). For the Queensland and New South Wales area of Australia he reported many "camps" containing from 5,000 to 10,000 individuals, and camps of 100,000 or more were not uncommon. All these would add up to a considerable population. The largest camp known on New Caledonia might have contained, at most, 4,000 animals, and only one camp of such size was inspected. The next largest camp observed contained approximately 1,500 animals. Most camps on the island did not have more than a few hundred (average around 300) animals. Besides being smaller, the camps on New Caledonia are apparently more widely spaced than those in Australia and elsewhere. *P. ornatus* makes up the bulk of the flying fox population on New Caledonia.

Although *P. ornatus* has a general distribution on New Caledonia, there is a marked fluctuation in numbers throughout the year for any one area. Ratcliffe (1931, p. 24) states that "all the four Australian species of flying fox seem to be migratory to a greater or lesser extent." Fluctuation in numbers in New Caledonia camps does not indicate a true migration; rather, simply a seasonal movement instigated by the presence or absence of food. The foxes seem to move northward in the spring and then gradually drift south during the summer or fall. This movement can be correlated to a certain extent with the maturing of flowers and the ripening of fruits, these constituting the main source of food for flying foxes. Flowers mature and fruits ripen in April through June (fall) in the southern portion of the island, and from a month to six weeks earlier in the northern part.

This correlation between plant development and flying fox movements is borne out by observations made at one daytime camp located in the southern portion of the island, near Paita. In general, more flying foxes were present at this camp in the winter than in the summer.

The following account of the numbers found on various visits to the camp not only illustrates the general seasonal movement of flying foxes but demonstrates a smaller in-season fluctuation in

numbers. The account pertains primarily to *ornatus*. When the camp was first visited on October 23 (spring season), between 15 and 25 flying foxes were present. On October 29, only one animal was found. On January 19, only two animals were present; but by March 31 (fall season), approximately 50 animals were occupying



FIG. 80. Rain-forest-like timber in center foreground, open niaouli woods in left background. Such areas are often chosen for camp sites by *Pteropus*. Dumbea Pass, New Caledonia.

the camp. On April 18, only 15 or 20 animals were found, but on April 28 between 75 and 100 bats were present. This was the largest number ever observed at this particular camp. After July, numbers at the camp decreased until in the following November only seven or eight animals were present. On two or three occasions in December, not a single animal was found.

Roosting sites and habits.—Like most flying foxes, *P. ornatus* is gregarious and congregates in roosting areas known as "camps." Since *ornatus* is a nocturnal animal, the camps are occupied during the daytime.

Ratcliffe (1931, p. 13) says of Australian species of flying foxes (*P. poliocephalus*, *gouldi*, *conspicillatus*, and *scapulatus*), "Seclusion

and shade seem to be the chief factors influencing the animals in the choice of a site for their daytime camp. Patches of dense rain forest . . . or mangrove are almost invariably selected. When these are not available, camps may be formed in tea-tree swamps, brigalow (*Acacia harpophylla*) 'scrub,' creek-bed vegetation such as she-oaks (*Casuarina* spp.), weeping willows, etc., and sometimes in the 'open' forest." The same criteria for selection of camp sites seems to hold true for *P. ornatus* on New Caledonia. There, the camps are located in heavy rain-forest-like timber (fig. 80) found in the runoff depressions on the mountain slopes and between the mountain ridges. These patches of heavy timber, ordinarily extending from the base to half to two-thirds of the way up the mountain, are composed of a variety of trees and shrubs. The principal species of trees are *Aleurites moluccana*, *Semecarpus atra*, and *Elaeocarpus persicifolius*. These camps frequently cover several acres. It was noted that *P. ornatus* ordinarily establish their camps near the head or upper limits of these forest patches. Only rarely, except for feeding purposes, were flying foxes found at the lower end of such areas; those that were found there were ordinarily single individuals.

Except for one instance, all camps observed on New Caledonia were in situations similar to that described above. This one exceptional roost or camp was located in a river bottom, but it offered fully as much protection and cover as the other sites, being in heavy timber (bottom land). A single animal was observed roosting in a mangrove swamp, but no evidence was secured to indicate that major camps were ever established in such environment on New Caledonia. Native French stated that single flying foxes (probably *ornatus*) sometimes roosted in the open niaouli (*Melaleuca viridi-flora*) woods; but they also indicated that these animals were found in such situations only in conjunction with extensive feeding on the niaouli flower.

The candlenut tree, *Aleurites moluccana*, is most frequently selected for roosting purposes, probably because it is the tallest tree in the rain-forest-like association.

Quoting Ratcliffe (1931, p. 13) again, "Once a definite camping site has been established, 'tradition,' or some sort of homing instinct, seems to be a powerful factor preventing its abandonment, even when it would appear to have become unsuitable in a matter of seclusion and shelter." The same may be said regarding *P. ornatus*. For instance, the camp located near Paita was visited repeatedly, and specimens were taken on nearly every occasion, yet there was

no indication of abandonment. In another case two Frenchmen, MM. Henri Berlioz and Auguste Le Bouhelke, knew of one big camp, which they visited every year previous to the war. When American troops were sent to New Caledonia, a division training area was established on and surrounding the site of this particular camp. If flying foxes occupied the camp during this period they



FIG. 81. *Pteropus ornatus*, showing method of moving around in trees, New Caledonia.

certainly were subjected to a great deal of disturbance, including artillery fire, small arms fire, exploding hand grenades, tank maneuvers, and probably considerable hunting pressure; yet, as soon as the area was abandoned by United States troops, the Frenchmen returned and found two or three thousand bats (their figures) occupying the old camp site.

Another camp had been used for so long (and perhaps by such a large number of animals) that the top branches of many of the trees were dead or devoid of vegetation. Ratcliffe (1931, p. 13) reports similar situations; he says, ". . . when a certain patch of vegetation has harboured a number of foxes for some time, the upper branches often become quite denuded of leaves, and thus provide no sort of protection from the sun." He further states (p. 14) that in one particular camp, where the branches of the trees were denuded, ". . . there is plenty of uncleared rain forest in the locality in which they could find adequate shelter." This statement also applies to the area observed on New Caledonia.

P. ornatus readily sense the presence of an observer in their camp. Perhaps the presence of the observer contributes to the restlessness of these animals in their daytime camps; at any rate, from observations made, it appears that there is more or less constant bickering going on in a camp at all times of the day. Sometimes camps can be located by the sounds emanating from them. Notes taken on one occasion, and here quoted, characterize the daytime camp conditions: "When the camp was first approached it was thought none were present. Then some were heard (2:00 P.M.) about 100 feet from their usual haunt. It was soon discovered that several trees within range of vision contained between 15 and 25 bats (all *ornatus*). Apparently sensing my presence the bats became rather restless; some clambered about (fig. 81) peering around. When one would climb near a sleeping individual, or a close neighbor would scratch itself, the disturbed one would voice its protest. Occasionally, a bat would take off and fly to another tree, this usually setting off quite a violent vocal protest."

Although *P. ornatus* is nocturnal by nature, single individuals can be seen in the air in the vicinity of camps at all times of the day, and single individuals were frequently collected after 2 o'clock in the afternoon while feeding, sometimes at some distance from the roost. The majority of this species start for the feeding grounds about one hour before sunset.

On two occasions observations were made to determine the nature of the morning flight (return) of flying foxes. On one of these occasions only negative data were secured, as the bats (*ornatus*) were already roosting when the camp was reached at 8 o'clock (about two hours after sunrise). On the other occasion no bats were present in the camp at 7:30 A.M., about one hour after sunrise, and none returned until about 9 A.M., when 75 to 100 came in (both *P. ornatus* and *P. geddiei*). Bats continued to come into the roost all morning, or at least until noon, when the junior author left. No concentrations (in individual trees), such as were ordinarily found, were formed that morning, probably because of the presence of the observer.

Breeding habits.—The data we secured on the breeding habits of *P. ornatus*, although not of a precise nature, generally substantiate the findings of Ratcliffe for Australian species, and Baker and Baker (1936) for *P. geddiei* and *P. eotinus* in the New Hebrides. In general, the breeding habits of *P. ornatus* are similar to those of all these species.

Ratcliffe found that in *P. gouldi* and *P. poliocephalus* the young were born in October (spring). In one species, *P. scapulatus*, the

breeding season was completely reversed. He found (p. 34) that "coition occurs in . . . *P. scapulatus* in October . . ." Baker and Baker show that *geddiei* and *eotinus* in the New Hebrides have a distinct breeding season that generally corresponds with that of *gouldi* and *poliocephalus* in Australia. Baker and Baker did not find any pregnant specimens in November, December, or January. A large portion of the conceptions in *geddiei* and *eotinus*, according to the Bakers, took place in February and March, and the young were born in late August or early September after a gestation period of about six months. Ratcliffe says that *poliocephalus* has a gestation period varying from six to six and one-half months.

WEIGHT AND CROWN-RUMP LENGTH OF FOURTEEN EMBRYOS (*Pteropus ornatus*)

| Date taken | Weight in gm. ¹ | Crown-rump length in mm. ² |
|--------------|-------------------------------|--|
| April 28 | 0.1± | 4.4 |
| June 3 | 2.1 | 31.5 |
| June 23 | 6.7 | 38.0 |
| July 1 | 10.6 | 44.0 |
| August 19 | 22.4 | 64.0 |
| August 19 | 25.0 | 63.0 (head broken) |
| August 19 | 26.0 | 62.0 |
| August 19 | 32.1 | 70.0 |
| August 19 | 53.5 | 91.0 |
| September 9 | 49.4 | 84.0 |
| September 25 | 77.3 | 93.0 |
| October 6 | 48.7 | 83.0 |
| October 6 | 69.0 | 94.0 |
| October 27 | 62.4 | 84.0 |

¹ Specimens preserved in alcohol, freed of fetal membranes and umbilical cord cut short. Liquid was drained off and excess surface liquid mopped off with a towel.

² Length measured in a straight line from vertex to tail root, with specimens extended as much as possible during measurement.

Data secured on *P. ornatus* (table above) show that this species follows much the same pattern as that shown for *geddiei* by the Bakers. No pregnant specimens were taken from November through March. Pregnancies were at their peak in June, July, August, and September. By October, young and lactating females without young were taken. One young, probably ten or fifteen days old, was taken in June, but this was an exceptional instance of early birth. Data secured on New Caledonia are not conclusive because of the limited number of specimens and the junior author's inability to do much collecting in the fall months (March and April), but when the weight and crown-rump measurement of the few embryo speci-

mens are graphed opposite the collecting dates, the relative progressive increase in weight and crown-rump length, together with the fact that no pregnant specimens were taken before April or after October, strongly suggests a gestation period of about six months (see fig. 82 and table, p. 321). This is similar to the gestation period suggested by the Bakers for *geddiei* in the New Hebrides.

Careful notes were not made on the condition of the testes of male *ornatus*, but it was noted that the testes of this species were not always in the scrotum. It is suspected, as Baker and Baker suggest, that the testes readily pass to and fro from the scrotum to the abdominal coelom, and thus may not necessarily indicate breeding condition. The Bakers (1936, p. 131) say of *geddiei*, "The cavity of the scrotum is widely open to that of the abdominal coelom, and the testes can readily pass to and fro. We therefore soon gave up recording whether they happened to be situated in the scrotum or not, since this depended on the pressure that happened to be exerted on them while the dead bodies were being carried back to camp. Writing of the Australian fruit bats in general, Ratcliffe says that, 'the testes of the male are withdrawn, or partially so, during the greater part of the year. On the approach of the breeding season they are protruded rather obviously in a naked scrotum.' We did not notice this phenomenon in *P. geddiei*."

Apparently *ornatus* does not breed until it is two years old. This conclusion is based on the collection of several animals classed as subadult or one-year-olds that were not in breeding condition, and observations made on a captive male *ornatus*. Five non-pregnant females, taken during the breeding season, were classed as subadults or yearlings because of their small size. Three small males, taken during the breeding season and definitely not juveniles, did not have a well-developed baculum; these were thought to be incapable of breeding and were classified as subadults or yearlings. The captive *ornatus*, secured when about twenty-five days old and kept for nearly ten months, had not developed sexually to any great extent at the end of that period. However, it must be recorded that this animal suffered from a severe malnutritional condition, noted when he died.

P. ornatus normally produce only one young at a birth. Ratcliffe (1931, p. 34) says of flying foxes in general, "The occurrence of twins, although definitely established, must be considered very exceptional." In *ornatus* multiple births may occasionally occur but certainly only rarely.

Upon birth the young cling to the under side of the female by claw, wing hook, and mouth. A tenacious grip is maintained on

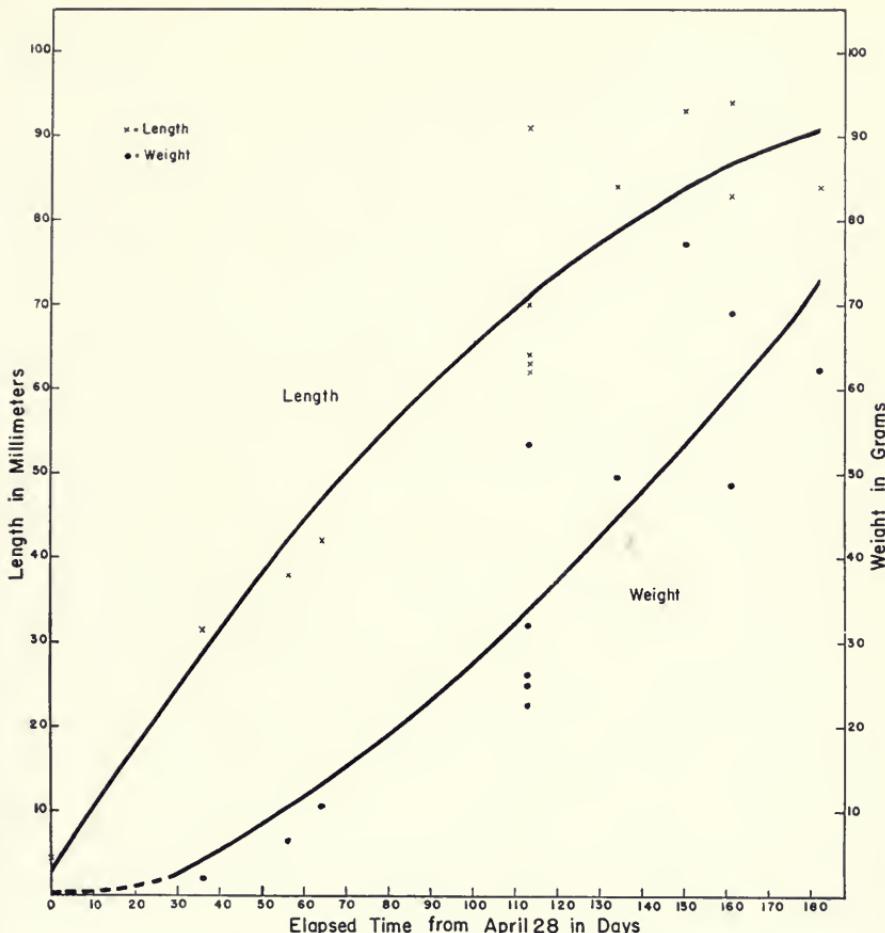


FIG. 82. Growth curves for *Pteropus ornatus* embryos, from data in table (p. 321). Curves fitted by method of least squares. Equation for length: $Y = 1.9646 + 0.8162X - 0.0018X^2$. Equation for weight: $Y = -4.4927 + 0.1897X + 0.0013X^2$. Below 30 days, equation for weight gives minus values, which are obviously incorrect.

one of the two teats that are located in the thoracic region. At least during the early life of the young, the mother keeps it completely covered with her wing during the day. Usually it was not known that an animal had young until the mother was collected.

Ratcliffe states that young of *Rousettus* sp. in captivity remained at the breast of the mother till the end of the fourth month. Of *P. poliocephalus* he says that the young remain with the mother between three and four months. Ratcliffe was not sure how long the young were carried on the nightly travels to the feeding grounds.

P. ornatus probably keep their young with them as long as *poliocephalus*; however, even in the earlier stages the mothers of this species apparently leave their young for part of the day, as evidenced by the taking of lactating females without young.

There is some tendency for the sexes of *P. ornatus* to segregate and scatter throughout the forest while the females are nursing their young, and during the preceding period of pregnancy, although such segregation is not clear cut. Ratcliffe states that females of Australian species segregate during these periods.

Food habits.—Because of the lack of facilities and the undifferentiated nature of stomach material, no attempt was made to determine food habits of flying foxes by stomach analysis. Some data were secured on this subject by observation.

P. ornatus were observed, or otherwise determined, to feed on the following fruit- and flower-bearing trees and shrubs of New Caledonia:

Fruits: Zhio or n'diu (*Elaeocarpus persicifolius*); *Semecarpus atra*; *Syzygium* sp.; guava (*Psidium Guajava*); mango (*Mangifera indica*); papaya (*Carica Papaya*); banana (*Musa* sp.); passion fruit (unidentified); Rubiaceae.

Flowers: Niaouli (*Melaleuca viridiflora*); coconut (*Cocos nucifera*); pecan (unidentified).

A pet *ornatus*, besides eating all the above-named fruits and flowers, ate apples, canned pears and peaches, figs, nut meats, and oranges. He also consumed with considerable relish such things as doughnuts, chocolate, popcorn, and chewing gum. He eventually developed a considerable dislike for apples.

Flying foxes do not actually eat their food in the ordinary sense; rather they chew it for the juices contained therein, and spit out the pulp. Frequently wads of spit-out pulp can be found under the trees in which there has been extensive feeding.

No observations were made on water consumption of wild flying foxes; however, judging from the quantities consumed by the pet *ornatus*, their water requirements are high. Ratcliffe states that water is taken on the wing, as they swoop low over the water and lap it up. Our pet lapped his water after the manner of a cat.

Association with other species.—*P. ornatus* were found in the same camp with *geddiei*; however, the two species ordinarily were segregated. They were found in the same tree on only one occasion; in this single instance one juvenile female *ornatus* was taken

with fifteen *geddiei* of mixed sexes and ages. In spite of these recorded associations, there may be some antagonism between the two species, for, when a pet *ornatus* (at six months of age) was introduced into the cage with a female *geddiei*, both developed an antagonistic attitude, and the *ornatus* developed a fear reaction, which was exhibited every time the *geddiei* came within his view thereafter.

Other observations.—Flying foxes have a musky odor, not altogether unpleasant but definitely noticeable. Their camps can frequently be located by the odor emanating from them. The odor given off by *ornatus* is similar to that of *geddiei*, although somewhat less strong.

Flying foxes normally hang head down, but when defecating or urinating they reverse their position and hang by the thumbs. This was observed in both the pet and the wild individuals.

Natives of New Caledonia repeatedly reported that flying foxes cluster (like a bunch of grapes) during cold or rainy weather. According to their accounts, forty or fifty bats sometimes hang together. Père Gagnaire, of Poya, told the junior author that "he once killed 68 bats with one shot" when he found them clustered one cold morning. Ratcliffe came across the same belief in Australia, but, like Ratcliffe, the junior author finds it hard to believe that these animals could stand the weight of others hanging to them. On the other hand, one wonders how such a widespread belief could persist unless there were some basis for it. On several occasions, particularly on cool or wet days, the junior author observed two *ornatus* hanging very close together (stomach to stomach) and on two occasions three bats were observed hanging stomach to stomach. MM. Berlioz and Le Bouhelke claimed to have seen six or seven hanging together but they further indicated that each bat hung from the branch. Once, the junior author killed sixteen flying foxes with one shot, but these animals were not clustered; there was simply a large number of bats in the tree.

Parasites.—*P. ornatus* was parasitized with bat ticks identified as *Cyclopodia oxycephala* Bigot, Family Nycteribiidae. All specimens taken were infested more or less heavily, but the bats did not seem to suffer any ill effects as a result of the parasitism.

***Pteropus geddiei* MacGillivray**

Pteropus geddiei MacGillivray, Zoologist, 18, p. 7134—Aneiteum, New Hebrides.

Specimens examined.—NEW HEBRIDES: Espiritu Santo Island, Segond Channel, 4 males, 6 females. NEW CALEDONIA: Near Noumea, 1 male, 1 female; near Paita, 1 male, 3 females; near La Foa, 1 male, 2 females; near Moindou, 6 males, 4 females. Total 29.

Measurements (3 adult males, 3 adult females from New Hebrides; 1 male and 2 adult females from New Caledonia in parentheses).—Forearm 157.8–169.1 (157.7–175.4). Skull: greatest length 71.4–74.6 (68.7–72.6); condylo-basal length 69.4–72.2 (66.2–70.6); palatal length 34.9–37.6 (34.1–36.7); interorbital width 8.8–9.6 (8.7–9.9); intertemporal width 6.4–7.6 (6.5–7.4); zygomatic width 36.4–39 (35.7–37.8); mastoid width 22–23 (20.9–23.8); width of brain case 22.8–24.7 (22.9–23.8); upper toothrow 26.8–29 (25.4–28.2); distance across canines 13.5–15.4 (13.5–14.7); across molars 19.3–20.3 (18.8–19.9); orbit to tip of nasals 24.3–25 (21.9–25.4).

Distribution and numbers.—On New Caledonia, *geddiei* is a relatively abundant species but it is not nearly so plentiful as *P. ornatus*; furthermore, it seems to be limited (at least for part of the year) to the central portion of the island. Besides specimens collected, one live specimen secured from a Frenchman was supposed to have come from Voh or Kone. Père Gagnaire, of Poya, informed the junior author that *geddiei* occurred there, but none were observed. Of approximately 1,500 flying foxes observed at Moindou, 75 to 80 per cent were *geddiei*, while at Paita, even if *geddiei* were present, 80 to 90 per cent of the animals were *ornatus*. From this and the foregoing, it has been concluded that the center of the New Caledonian distribution of *geddiei* is in the vicinity of Moindou, the central part of the island. This species probably occurs at as high elevations as *ornatus* but definite data were not secured.

According to Dwain W. Warner, and Baker and Baker (1936), *geddiei* is the most abundant species on Espiritu Santo, New Hebrides.

As indicated by observations made at Paita, it is evident that, like *ornatus*, *geddiei* fluctuates in numbers in a given camp and moves seasonally. Specimens of *geddiei* were first taken near Paita by a friend on June 9, at which time, he said, there were approximately 150 *geddiei*. On June 14, approximately 25 *geddiei* were found there. On July 4, between 700 and 800 *Pteropus* were present, of which only about 12 per cent (100) were estimated to be *geddiei*. On July 11, a few *geddiei* (estimate not given) were present amongst 75 to 100 flying foxes. None were observed at Paita again.

Roosting habits and association with other species.—Like *P. ornatus*, *geddiei* occurs in camps, where it is, at least sometimes, associated

with *ornatus*. In two instances in which *geddiei* was taken by the junior author (at Moindou and Paita) both species were present; however, the two species occupied separate sections of the camp (see single exception, p. 324). This species is similar to *ornatus* in its roosting habits and locates its camps in the same habitat.

Breeding habits.—Only a few specimens of *geddiei* were taken on New Caledonia. As a consequence little information was secured on breeding habits. The breeding season for *geddiei* on New Caledonia occurs during the same general period as it does for *ornatus* on New Caledonia and *geddiei* in the New Hebrides, but the young may develop at a slightly later date on New Caledonia as indicated by one *geddiei* embryo taken in June. This one specimen weighed 0.3 grams and the crown-rump length was 13.4 mm. (Weight was of preserved specimen with fetal membrane eliminated, umbilical cord cut short, liquid drained off, and excess surface liquid mopped off with a towel. Crown-rump length measured in a straight line from vertex to tail root. Specimen extended as much as possible.) Average weight of 13 *geddiei* embryos taken in June by the Bakers was approximately 20 grams. Presumably these specimens were weighed before preservation, and the placenta was included. No measurements were given. Females of this species taken in the New Hebrides in May were pregnant. Only one young is produced at a birth. Like *ornatus*, this species probably does not breed until it is two years old.

Food habits.—No observations were made on food habits in the wild, but a captive *geddiei* consumed the same food items as a pet *ornatus*.

Parasites.—*P. geddiei* was parasitized with bat ticks, probably *Cyclopodia oxycephala* Bigot.

Pteropus anetianus aorensis Lawrence

Pteropus anetianus aorensis Lawrence, Proc. New England Zool. Club, 23, p. 66, 1945—Aore Island, southeast corner of Espiritu Santo Island, New Hebrides.

Specimens examined.—NEW HEBRIDES: Segond Channel, Espiritu Santo Island, New Hebrides, 5 males, 2 females.

Pteropus anetianus aorensis Lawrence comes from an area in the New Hebrides between the type locality of *P. anetianus* Gray, from Aneiteum Island, and *P. eotinus* Andersen, from Aurora Island. Miss Lawrence has kindly compared most of the Chicago Natural History Museum series with the type and identified them as *aorensis*.

On the basis of present material compared with the description of *eotinus*, the subspecies *aorensis* appears recognizable. *P. eotinus* was described from two specimens skinned from alcohol with the comment "but the colour of the fur is probably uninfluenced by the preserving fluid." It is generally conceded today that alcohol does affect color. A series of topotypes of *eotinus* would help to clarify the differences between these three forms.

Measurements.—Forearm 125.6–136. Skull: greatest length 59.5–63; condylo-basal length 57.2–60.1; palatal length 31.5–34; front of orbit to tip of nasals 17.4–19.3; interorbital width 8.9–9.7; intertemporal width 6.6–7.5; zygomatic width 33.1–37.6; width of brain case at zygomata 21–23; upper toothrow 21.9–23.6; width across canines 12.6–14; across molar $\frac{1}{2}$, 17.1–18.

Life history.—*Pteropus anetianus aorensis*, although numerous, is less plentiful than *geddiei* on Espiritu Santo. According to Dwain Warner's notes, it precedes *geddiei* to the feeding grounds (coconut groves) by several moments.

Two females taken in May at Segond Channel were pregnant, indicating a breeding period similar to that of *P. geddiei* and *P. eotinus* (= *P. a. aorensis*) as demonstrated by Baker and Baker (see discussion, p. 320).

***Pteropus macmillani* Tate**

Pteropus macmillani Tate, Amer. Mus. Nov., No. 1213, p. 1, December 8, 1942.

Specimens examined.—NEW CALEDONIA: 6 miles east of Noumea, 1 subadult male.

The type specimen was collected at Tao, slopes of Mount Panie, 4,000 feet, in the northern part of the island. Our specimen came from the southwest corner of the island. It agrees with the description of the type in general but is of a different color and may represent a dark phase. The general color is black, lightened a little by the long silvery gray tips on some of the hairs in the mantle and on the back. The legs and toes are densely covered with woolly black hairs. The under side is lightened by long golden hairs and golden tips on the hairs. The type was described as dark brownish gray.

Measurements.—Forearm 106.1. Skull: greatest length 49.8; condylo-basal length 47; palatal length 26.8; zygomatic width 25.5; interorbital width 6.4; intertemporal width 6; width of brain case 18; upper toothrow 16; width across canines 10; across molar $\frac{1}{2}$, 12.8.

Life history.—The one specimen collected was taken in open niaouli woods near Noumea at approximately 1,500 feet elevation, while the type specimen was taken at 4,000 feet elevation on Mount Panie (near Hienghene). This would indicate a wide distribution as regards both elevation and area. Natives of New Caledonia apparently know of this bat and regard it as scarce. French people living on New Caledonia apparently do not know of its existence.

Pteropus rayerni Gray and Pteropus howensis Troughton

The junior author was afforded an opportunity to visit several of the Solomon Islands during July and August, 1945. *Pteropus rayerni* and *P. howensis* were collected and the specimens deposited with the United States National Museum.

P. rayerni was taken from a night flight on the Tenaru River, Guadalcanal. The specimens were associated in flight with other unidentified flying foxes. The one female taken (July 20) was pregnant, with a well-advanced embryo. The weight (after preservation) of this embryo is 51 grams. The crown-rump length is 68 mm., or about 32 per cent of the length of the mother (standard body length 215 mm.).

P. howensis was taken on Ontong Java (Lord Howe Island). *P. howensis* could in no way be considered abundant on Ontong Java, but one could not expect them to be so, since the island is a coral atoll devoted almost exclusively to the production of coconuts. The specimens taken and observed were scattered. Perhaps this circumstance was related to the fact that females (two taken) were pregnant (August 5 and 6), and segregation of the sexes might have been in effect. Embryos were well advanced. Embryo weights and measurements are as follows: weight in grams of embryo (in alcohol) 20, 29; crown-rump length of embryo (after preservation) 43, 51; standard body length of mother 182, 187; percentage of length of mother 23.6, 27.3.

Notopteris macdonaldi neocalledonica Trouessart

Notopteris macdonaldi neocalledonica Trouessart, Bull. Mus. d'Hist. Nat., Paris, 14, p. 257, 1908—Adio Caves, Nekliai Valley, near Poya, New Caledonia.

Notopteris neocalledonica K. Andersen, Cat. Chirop., 1, p. 799, 1912; Revilliod, in Sarasin and Roux "Nova Caledonia," Zool., 1, p. 350, 1914—Hienghene, New Caledonia.

Specimens examined.—NEW CALEDONIA: 18 miles northeast of Poya, 2 females, each with one young; 2 miles south of Hienghene, 2 females, 4 subadult females.

The lack of adequate material caused Andersen to question the validity of this subspecies. Since then Revilliod has published measurements clearly showing the difference in size between the two forms. This has been confirmed by a comparison of the New Caledonia specimens with a series of 22 adult *macdonaldi* from the Colombo Cave, near Suva, Viti Levu Island, Fiji Islands.

The forearm in Fijian *macdonaldi* is always longer than in *neocalledonica*, 63.9–71.3 in 22 *macdonaldi*, 60.5–61.5 in 2 female *neocalledonica*. The skull of *macdonaldi* may, in small adult females, be about the same size as in female *neocalledonica*. There are no adult male *neocalledonica* available for comparison. It has been noted in the series of *macdonaldi* that male skulls show strong sagittal crests starting at the frontals and increasing in size to the well-developed lambdoidal crests. The skulls of the females have moderately developed lambdoidal crests but no indication of sagittal crests. Males also have more widely expanded zygomatic arches.

The following measurements are those of the two adult female *neocalledonica* and, in parentheses, the smallest adult female and largest adult male from the series of 22 *macdonaldi*:

Measurements.—Forearm 60.5–61.5 (63.9–71.3). Skull: greatest length 32.9–33.7 (33.9–37.6); condylo-basal length 30.2–31.9 (31.5–34.6); palatal length 14.1–14.6 (13.9–15.9); interorbital width 6.1–6.4 (6.3–7.3); intertemporal width 6.5–8.3 (7.4–8.3); zygomatic width 16.3–16.6 (17.9–21, in another male 21.4); width of brain case 12.9–13.4 (13.8–14.5); upper toothrow 8.9–9.2 (9.6–10.2); width across canines 6.2–6.4 (6.6–7.8).

Distribution.—This long-tongued fruit bat occurs in caves on New Caledonia. The extent of its distribution on the island is not definitely known, although specimens were secured from widely separated points, Hienghene and Poya. Natives at Houailou claimed to know the bat but it is not clear whether or not they understood what animal was being described to them. Natives at Moindou did not know of its existence. Père Gagnaire, at Poya, said that these bats occupied only one cave out of several hundred in the valley in which specimens were collected.

Roosting site and habits.—Natives at Hienghene and Houailou said that this bat sometimes lives in hollow trees.

At Hienghene approximately 200 long-tongued bats were found in a small opening (about 4 feet in diameter by about 10 feet deep) in the second room of a two-room cave. Before the animals were much disturbed, it was noted that they were resting in masses of

several individuals. At Poya, where there were about 300 bats of this species in two rooms of the cave, they hung on the walls in clusters containing from 5 or 6 to as many as 20 or 25. The roosting habits of this bat resemble those of some of the Microchiroptera, at least the Mexican free-tailed bat (*Tadarida mexicana*).

Breeding habits.—Pregnant females secured in July and two young taken in August indicate that this species has a breeding season similar to that of *Pteropus*, although the young are born earlier in the spring than *Pteropus*. No data were secured on the gestation period. This species normally has only one young at a birth, and the young attach themselves to the female in the same manner as in *P. ornatus*.

The seven *Notopteris* secured at Hienghene were all females. At Poya, 8 specimens, 3 females (2 with young) and 5 males, were taken. It can be assumed that the sexes probably do not segregate at any time. Both males and females were taken out of a single cluster.

Food habits.—One female, kept alive for three days, was fed on the juices from canned fruits (pears and peaches) and a mixture of sugar and water. She refused solid food. Frequent feedings were essential and death was partly attributed to insufficient quantity of food. No other data were secured on food habits of this species.

Parasites.—Specimens of *Nycteribosca rouxi* Falcoz were collected on these bats.

Hipposideros cervinus Gould

Rhinolophus cervinus Gould, Mammals of Australia, 3, text to pl. 34, 1863.

Hipposideros cervinus Jentink, Nova Guinea, 5, liv. 2, p. 363, 1903.

Specimens examined.—NEW HEBRIDES: Espiritu Santo Island, Segond Channel, 1 male, 2 females.

Life history.—See under next species.

Aselliscus tricuspidatus novehebridensis subsp. nov.

Type from cave on Segond Channel, Espiritu Santo Island, New Hebrides. No. 55219 Chicago Natural History Museum. Skin and skull, adult male. Collected May 27, 1945, by Dwain W. Warner and A. J. Nicholson. Original number 1030.

Characters.—Like *tricuspidatus* but larger throughout.

Color.—Mummy Brown above and Buffy Brown below. Another specimen is slightly darker.

Skull.—Maxilla longer than in *tricuspidatus* so that skull is more sloping in front of rostral swellings. Depression behind rostral swellings shallower. Otherwise like *tricuspidatus* but larger.

Measurements (maximum-minimum of *tricuspidatus* in parentheses).—Forearm: 40.2–41.5 (37.7–40 in ten specimens); third metacarpal 31, first phalanx 13, second phalanx 13.8; fourth metacarpal 30.2, first phalanx 9.4, second phalanx 8; fifth metacarpal 27.5, first phalanx 9.9, second phalanx 10. Tail 20.8; foot 8; tibia 15 (12.8–14.6); calcar 11. Skull: greatest length 15.5–15.6 (14.3–14.6); condylo-basal length 13.8–13.8 (12.2–12.5); palatal length 2.7–3 (2.3–2.5); width of rostral swellings 4.8–5 (4.6–4.6); interorbital width 1.8–1.9 (1.8–1.8); zygomatic width 7.7–7.9 (7–7); mastoid width 6.9–7.1 (6.5–6.8); width of brain case 5.9–6.3 (5.5–5.6); upper toothrow 5.5–5.7 (4.9–5.1); width across canines 3.9–4 (3.5–3.6); across last molars 5.5–5.6 (4.8–4.9).

Remarks.—The known range of *Aselliscus tricuspidatus* includes Amboina Island (the type locality), Buru Island, New Guinea, Duke of York Island, and the Solomon Islands. It has not been recorded from New Hebrides previously, where it appears to be represented by this slightly larger subspecies.

The original description of *tricuspidatus* gave the length of the forearm as "1 pouce, 4 ligues" (about 35 mm.). In Dobson's catalogue the length is given as 1.6 inches (between 39 and 40 mm.). The numerous other published records contain no measurements of either skin or skull.

Distribution and association.—*Hipposideros cervinus* and *Aselliscus tricuspidatus novehebridensis* were taken together in a cave at Segond Channel, Espiritu Santo, New Hebrides, by Dwain W. Warner. It was not determined whether or not these two species were segregated before being disturbed. Baker and Bird (1936) found *H. cervinus* associating with *Miniopterus australis* in a cave at Hog Harbour, Espiritu Santo, New Hebrides; occupation of the same cave by two or more species is not unexpected.

Breeding habits.—Data secured by Baker and Bird (1936) at Hog Harbour are corroborated by two adult females (*H. cervinus*), which were not pregnant, taken in late May. The only pregnant specimen they secured was taken in October (specimens taken in March, April, and June; none in July, August, or September). They took two females with young in December. Males taken in March, April, and June had large testes, and spermatozoa in abundance were noted.

Miniopterus australis australis Tomes

Miniopterus australis Tomes, Proc. Zool. Soc. London, p. 125, 1858—Loyalty Islands.

Specimens examined.—NEW CALEDONIA: Mount d'Or, 27 males (21 alc.), 18 females (7 alc.); one mile north of Hienghene, 5 males (alc.), 5 females (alc.); Dumbea, 6 females; four miles north of Nepoui, 3 males, 4 females; four miles west of Paita, 3 males, 3 females; eighteen miles northeast of Poya, 2 males; two miles west of Bouloupari, 4 males, 3 females; five miles east of Noumea, 1 male. Total 84.

Measurements and life history.—See under *Miniopterus macrocneme*.

Miniopterus macrocneme Revilliod

Miniopterus macrocneme Revilliod, in Sarasin and Roux "Nova Caledonia," Zool., 1, pt. 4, p. 360, pl. X, figs. 5, 6, 11 (skull, teeth and tragus), 1914—New Caledonia.

Specimens examined.—NEW CALEDONIA: six miles south of Hienghene, 1 male (alc.); one mile north of Hienghene, 2 females (alc.); two miles south of Hienghene, 1 female (alc.); seven miles north of Hienghene, 7 males, 4 females; two miles west of Bouloupari, 12 males (6 alc.), 11 females; Mount d'Or, 2 males (1 alc.), 5 females (3 alc.). Total 45.

MEASUREMENTS

| | <i>australis</i> | <i>macrocneme</i> |
|----------------------------|------------------|-------------------|
| Forearm..... | 36.3–39.2 | 39.6–42.0 |
| Tibia..... | 14.8–16.2 | 17.7–19.9 |
| Skull | | |
| Greatest length..... | 13.6–14.2 | 13.8–14.2 |
| Condylo-canine length..... | 11.9–12.5 | 13.3–13.8 |
| Interorbital width..... | 3.0–3.4 | 3.5–3.6 |
| Zygomatic width..... | 7.0–7.4 | 7.7–7.8 |
| Mastoid width..... | 7.2–7.6 | 7.7–7.8 |
| Width of brain case..... | 6.6–6.9 | 7.1–7.3 |
| Upper toothrow..... | 5.1–5.3 | 5.4–5.5 |
| Width across canines..... | 3.7–3.9 | 3.9–4.1 |
| Width across molars..... | 5.3–5.5 | 5.6–5.9 |

This large series completely bears out the validity of the characters that were ascribed to this species by Revilliod. The forearm and tibia are always longer than in *australis*: Forearm 39.6–42, tibia 17.7–19.9 in *macrocneme* against 36.3–39.2 and 14.8–16.2 in *australis*. The skulls are about the same in over-all length, but

that of *macrocneme* is longer in its condylo-canine length and is broader in all proportions, with a higher brain case.

Distribution.—Two bent-winged bats, *Miniopterus a. australis* and *M. macrocneme*, are distributed throughout New Caledonia. The two species frequently occur together in the same cave at the same time. Out of seven collecting sites at which more than two individuals were taken, both species were taken in four instances, *M. macrocneme* only were taken in one instance, and *M. australis* only in two instances.

Roosting sites and habits.—These bats are found in caves, culverts, and houses, and perhaps in hollow trees, although none were taken from trees. The normal habitat seems to be dark caves. Caves at Bouloupari, Nepoui, Poya, and Hienghene were typical limestone caverns. Both species were taken at all these caves, except at Poya where only two specimens of *australis* were taken, but *macrocneme* probably occurs there. Three specimens (*australis*) brought in by natives were taken in a house in Noumea. These may have got into the house accidentally, but at Paita and at Poya *Miniopterus* were known to live between the walls of a house. A few individual specimens (both species) were taken from a man-made tunnel near Noumea, although the guano deposit indicated that this site had at one time been occupied by a considerable number of bats. At Paita, where specimens were occasionally collected, the animals occupied a slightly darkened cliff in a large rock. Likewise, at Dumbea, *Miniopterus* were found in a more or less open situation. The fact that only *australis* were taken at the last two sites may indicate more adaptability.

In addition to being found in the above described situations, both of these bats occupy open caves (or horizontal depressions) and culverts at night. Several such places were examined—a half dozen or more culverts and two caves. At Mount d'Or, coal miners had made in the face of the rock a hole some seven feet in diameter and perhaps fifteen feet deep (fig. 83). The other was a tidal cave at Hienghene about sixty feet deep by thirty feet high. Both these situations were well lighted during the day, but on no occasion were they occupied except at night. The several culverts examined contained small deposits of guano and it was assumed that bats occupied them at night.

Numbers present in either the daytime or night-time roosting sites were never very large, at least in comparison to bat caves of the United States, where thousands, even millions, are sometimes found.

Numbers found on New Caledonia were even smaller in comparison to the numbers found at Hog Harbour, Espiritu Santo, New Hebrides, where Baker and Bird estimated as many as 5,000 (mostly *M. australis*) in one cave. The cave at Bouloupari never contained more than 400 or 500 bats. The largest number observed at Paita



FIG. 83. Cave made by coal-mining, Mount d'Or, New Caledonia, nighttime resting site for *Miniopterus a. australis* and *M. macrocneme*.

was 300 or 400, and about 200 was the largest number seen at Mount d'Or. At other places there were only 20 or 30, or fewer, present.

Periodic visits to three collecting sites (both daytime and nighttime roosts) revealed a considerable fluctuation in numbers. Fluctuations in numbers at the Mount d'Or site might be expected, since this was used only at night. Here, numbers varied from 35 on June 29, to about 100 on July 5, back to 60 on July 12, to approximately 200 on July 19; on July 24 only about 15 were present. On the other hand, at Bouloupari, a daytime resting cave, one would expect more constant numbers; but this was not the case. On

October 30, from 200 to 300 bats occupied this cave, while on November 18 only 15 or 20 were present. On January 1, only 5 or 6 adults were observed, although there were between 100 and 150 naked young attached to the ceiling at one place. In March some 300 or 400 animals were present (of 12 collected, all were subadult) and in January the following year, 10 or 12 bats were observed. At Paita (also a daytime resting site), where a closer check was maintained, numbers varied even more than at Bouloupari or Mount d'Or. On October 22, from 200 to 300 bats were present; on October 24 and 27, there were no bats; on December 10, from 200 to 300; on December 31 and January 19, no bats; on April 18, about 50; on April 28, about 75; and on May 27, a few.

Of course there were probably innumerable other undiscovered places that these bats could occupy when not present in the locations visited, but in view of the roosting habits of some other insectivorous bats, especially the Mexican free-tailed bat, one wonders why *Miniopterus* does not return to the same site day after day.

Breeding habits.—Baker and Bird (1936, p. 159) came to the following conclusions regarding the breeding habits of *M. australis* at Hog Harbour, Espiritu Santo, New Hebrides:

"(2) In the remarkably unvarying tropical climate of Hog Harbor, Espiritu Santo, New Hebrides ($15^{\circ} 15'$ S. in the Pacific), the insectivorous bat *Miniopterus australis* presents a very sharply defined annual breeding season.

"(3) Copulation occurs in the part of the year corresponding with the southern spring.

"(4) Fertilization and development of the embryo proceed without delay. There is no evidence of prolonged storage of sperms in the female, though a few are found in the uterine glands during early pregnancy."

Baker and Bird secured the first pregnant females of *australis* in September and continued to take pregnant females through December. The peak was reached in November, when 89 per cent (junior author's calculation) were pregnant. On New Caledonia, no pregnancies were noted until October, although a limited number of females were examined on September 3 and September 21. The peak period of pregnancy (both species) on New Caledonia was in December. Baker and Bird thought the young of *australis* in the New Hebrides were born in the latter part of December, after a gestation period of approximately 120 days. On New Caledonia, one nursing female (*australis*) was taken on December 10, but the

majority of the nursing females (both species) were taken in January. The breeding season for *Miniopterus australis* and *M. macrocneme* on New Caledonia, although limited to a definite season, is approximately one month later than in the New Hebrides.

The young of *Miniopterus* are born naked, and probably take about as long to develop a fur covering as other species. On January 14, at Bouloupari, probably from 100 to 150 naked young were attached to the ceiling of the cave. This mass of young covered an area about ten inches in diameter. Only one adult was in attendance, as noted elsewhere, and very few other adults were observed in the cave. The observation was made at 3:30 P.M., before the adults ordinarily started feeding. Just why more females were not in attendance is not known. In the Mexican free-tailed bat, from observations of the junior author, only rarely will an adult leave the cave, although females will leave their young and fly around the cave when disturbed during the daytime.

Baker and Bird (1936) came to the positive conclusion that in *australis* fertilization and development of the embryo immediately follow copulation. On New Caledonia no microscopic examinations were made, and observations made there on both sexes during July and August point to the need for further investigation to substantiate this point. On July 5 and July 12 about 50 bats (both *australis* and *macrocneme*) were caught and checked for sex. On both occasions, the penis of nearly all males was erected, and the vagina of females was open and moist. This condition was not noted on July 24, a cold evening, when nine specimens (5 males and 4 females) were examined, but it was noted again on August 10 and September 3. The condition was not evident at other times of the year.

Association with other species.—*Miniopterus* were found in association with *Notopteris*, but the two genera were always segregated.

Parasites.—*Miniopterus* were parasitized with bat ticks of two families: Nycteribiidae, *Nycteribia (Listropodia) sarasini* Falcoz and *Penicillidia oceanica* Bigot; and Streblidae, *Nycteribosca surcoufi* Falcoz. Like *P. ornatus*, *Miniopterus* is normally heavily parasitized but apparently suffers no ill effects.

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